

VOLTAGE LEVEL TRANSLATION CIRCUITS

CLAIM OF PRIORITY

Priority is claimed from U.S. Provisional Application No. 60/174,695 filed January 6, 2000.

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TECHNICAL FIELD

The present invention relates to the field of the operation of integrated circuits; and more particularly, relates to the adaptation of integrated circuits to work with power supplies having incompatible configurations and/or voltage levels. In both cases, the incompatibility is overcome by using voltage level translation.

BACKGROUND

In consumer electronics where low cost is an important engineering parameter, it is not uncommon to design using low cost parts in a manner in which the part was not designed to be used. Such a case can be where the power supply for a device has been designed for other purposes and it becomes necessary to use this seemingly incompatible power supply for providing an auxiliary feature. Such a case can be for a DVD player where the power supply is a balanced split level power supply, i.e., ± 5.0 volts with a center tapped ground, and it is desirable for cost reasons to use an integrated circuit which is designed for a single ended power supply with input and output coupling capacitors, which are desirable to eliminate. Such input and output coupling capacitors represent an extra parts cost and also can take up printed circuit board space which sometimes is very limited. Moreover, if the input and output capacitors are electrolytics, they are particularly larger than other capacitors and represent an additional reliability problem which is desirable to eliminate.

Additionally, the incompatibility of power supply and integrated circuit configurations can occur in, for example, a digital circuit system, where various subsystems operate with different power and voltage requirements. Some integrated circuit protocols and systems require a supply voltage with a V_{cc} (the positive rail voltage) of 3.3 volts and a V_{ss} (the lower rail voltage) of ground potential, while others may require a V_{cc} -to- V_{ss} voltage of 5.0 volts or 2.9 volts.

Still further concerning incompatible voltages available from a power supply, many integrated circuits are extremely sensitive to over-voltage or over-current, since

[illegible]

5 such overages can not only provide incorrect results (particularly if the integrated circuit is digital) but can also cause physical damage to the integrated circuit. Most processors have voltage and current ratings that may not be exceeded by even a little bit without causing severe damage to the integrated circuit. For example, it is not uncommon for microprocessors designed for operating at a power supply voltage of
10 3.3 volts to be damaged by application of signals in excess of a peak to peak of 3.45 volts when reading data from RAMs in which the high/low voltage differential is 5.0 volts. Therefore, closely limiting the voltage supply levels to meet specification is essential to the operation of integrated circuits.

15 SUMMARY OF THE INVENTION

A first embodiment of a voltage level translator is presented for operating an operational amplifier integrated circuit designed for operation with a single ended power supply, to operate with a split level power supply having a center tapped ground. A first polarity power supply terminal of a operational amplifier integrated
20 circuit is connected to a first polarity of the of the split level power supply, and a second polarity power supply terminal of the operational amplifier integrated circuit is connected to an second polarity of the power supply, with a signal input terminal of the operational amplifier being connected to the center tapped ground.

A second embodiment of a voltage level translator is presented to permit an
25 integrated circuit having a predetermined maximum voltage rating to be operated with a split level power supply having a power supply voltage greater than the voltage rating, wherein a first voltage translation zener diode is coupled in series between a first polarity of the power supply and an appropriate first polarity terminal of the integrated circuit, and a second voltage translation zener diode is coupled in series
30 between a second polarity of the power supply and an second polarity terminal of the integrated circuit,

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partial schematic,-partial block diagram of a prior art circuit.

35 Fig. 2 is a schematic of the amplifier of Fig. 1 incorporating the two translation circuits according to aspects of the present invention.

5 DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Fig. 1 is a prior art partial schematic,-partial block diagram of an applications circuit for an LM4881 integrated circuit, as recommended by the manufacturer of the integrated circuit, ©1997 National Semiconductor Corporation USA., and appropriately modified to comply with patent application requirements.

10 Referring to Fig. 1, an amplifier system, generally designated 10, includes an integrated circuit chip 12, which, in the exemplary embodiment, provides a pair of operational amplifiers 14R, 14L for respective L and R stereophonic amplification and sound reproduction. Signals R and L are coupled to inverting inputs 17R, 17L of respective amplifiers 14R, 14L through respective coupling capacitors 18R, 18L and
15 isolation resistors 20R, 20L. Output signals of amplifiers 14R, 14L at terminals 15R, 15L, drive respective loudspeakers 16R, 16L through coupling capacitors 22R, 22L. Loudspeakers 16R, 16L in the present case are earphone speakers.

Power for this arrangement is provided by a single ended power supply (not shown), with one side grounded at node 24, and positive voltage V_{DD} provided at node
20 26. Resistors 28R, 28L form a divider for providing a virtual AC reference signal ground at their junction for non-inverting terminals 30R, 30L through coupling capacitor 32. Power supply decoupling capacitor 33 prevents high frequency common mode feedback through the power supply. Resistors 36R, 36L in parallel with respective high frequency roll-off capacitors 38R, 38L, from respective output terminals 15R, 15L,
25 to inverting terminals 17R, 17L and isolation resistors 20R, 20L, provide negative signal feedback and prevent oscillation with a high frequency roll-off. Resistors 40R, 40L provide a DC return for leakage currents thus improving DC stability. Shut-down circuit 41 is internal to integrated circuit 12.

Particular note should be made of DC blocking, coupling capacitors 18R, 18L,
30 22R, 22L as well as AC ground coupling capacitor 32. By the voltage translation disclosed in connection with Fig. 2 of the circuit of Fig. 1, so that the circuit is powered by a split voltage power supply with a center tapped ground, these five coupling capacitors are eliminated, as will be discussed below.

The single-ended power supply used for Fig. 1 (not shown) and the split voltage
35 power supply with a center tapped ground (not shown) used for Fig. 2, are both well known power supply configurations which can be found, inter alia, in the Motorola™ Silicon Rectifier Handbook, ©1966, at pages 4-10 and 6-4 respectively. The single ended power supply can be a full wave or full wave bridge power supply with a single

5 DC polarity to ground. The "split voltage power supply" is commonly referred to as a full wave bridge doubler, generating opposite DC polarities with respect to an AC input lead which serves as ground. The ground serves as a center tapped AC ground return at the junction of series power supply capacitors, as well as a DC ground for the plus and minus DC power supply voltages.

10 The device into which the described headphone amplifier is to be installed, is a DVD player. One of the "incompatibility" problems is that the configuration of the DVD power supply is a "split voltage power supply" which is not compatible with the integrated circuit, which was designed for a single ended power supply, as discussed in Fig. 1. The second of the "incompatibility" problems is that once the configuration
15 incompatibility problem is overcome, the power supply voltages of the second power supply exceeded the maximum voltage specifications for the chosen integrated circuit. Both problems of "incompatibility" are overcome by the voltage translation circuits shown in Fig. 2, and discussed and claimed below, wherein like members to the members of Fig. 1 are given like numeral designations.

20 Referring now to Fig. 2, the circuit of Fig. 1 is voltage translated to be used with a split voltage power supply having plus and minus voltages available with a center tapped ground, wherein node 26 is connected to the plus voltage supply, node 24 is connected to the negative voltage supply and ground node 40 is connected to the center tapped ground. In this way, the voltages of the integrated circuit are translated
25 negative by one half the total voltage of the single ended supply of Fig. 1.

Since the ground terminal is now an actual ground voltage of the split level power supply instead of a virtual ground for the single ended power supply as provided by divider resistors 28R, 28L and capacitor 32, the DC blocking capacitors 18R, 18L, 22R and 22L are no longer required because the AC ground is at the power supply
30 voltage of DC ground. Since the AC and DC grounds are now at the same DC voltage, capacitor 32 also becomes unnecessary.

Having solved the configuration "incompatibility" problem and saved five coupling capacitors by voltage translation, this leaves the voltage level "incompatibility" problem. The present invention also discloses a system comprising a level translator
35 circuit having level translators provided by a zener diode conducting in the zener region, with each zener diode reducing the voltage level on one side of the split level power supply applied to integrated circuit 12. The translation of voltages from a first voltage level to a second voltage level is provided by generating a zener voltage and

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2629 2630 2631 2632 2633 2634 2635 2636 2637 2638 2639 2640 2641 2642 2643 2644 2645 2646 2647 2648 2649 2650 2651 2652 2653 2654 2655 2656 2657 2658 2659 2660 2661 2662 2663 2664 2665 2666 2667 2668 2669 2670 2671 2672 2673 2674 2675 2676 2677 2678 2679 2680 2681 2682 2683 2684 2685 2686 2687 2688 2689 2690 2691 2692 2693 2694 2695 2696 2697 2698 2699 2700 2701 2702 2703 2704 2705 2706 2707 2708 2709 2710 2711 2712 2713 2714 2715 2716 2717 2718 2719 2720 2721 2722 2723 2724 2725 2726 2727 2728 2729 2730 2731 2732 2733 2734 2735 2736 2737 2738 2739 2740 2741 2742 2743 2744 2745 2746 2747 2748 2749 2750 2751 2752 2753 2754 2755 2756 2757 2758 2759 2760 2761 2762 2763 2764 2765 2766 2767 2768 2769 2770 2771 2772 2773 2774 2775 2776 2777 2778 2779 2780 2781 2782 2783 2784 2785 2786 2787 2788 2789 2790 2791 2792 2793 2794 2795 2796 2797 2798 2799 2800 2801 2802 2803 2804 2805 2806 2807 2808 2809 2810 2811 2812 2813 2814 2815 2816 2817 2

This possible over-voltage condition is solved by adding two 2.4 volt zener diodes 50, 52 poled in their zener polarity, each added in series with one side of the split power supply voltages. The two zener diodes thus provide a $2 \times 2.4 = 4.8$ volt drop to bring the maximum power supply voltage to 5.2 volts across the integrated circuit 12. Thus, each of the split voltage power supply sides of ± 5.0 volts are translated downward to ± 2.6 volts. Zener diodes 50, 52 are selected to be in the zener region of their characteristic at the DC current drawn by the amplifiers 14R, 14L. In the alternative, non-zener silicon diodes, poled in the forward conducting direction, can also be used (not shown), e.g. four diodes each having a 0.6 voltage drop, would provide a 2.4 volts drop instead of a zener diode. The value of the zener voltages or the number of forward biased silicon diodes can be chosen according to the level of voltage drop desired. However, using zener diodes, provides better power supply regulation.

The present embodiment(s) show a voltage translation from an over-voltage power supply which is a split level power supply. It is within the contemplation of the present invention that a single ended over-voltage power supply can be used in which case only a single zener diode need be used.